Flow and Living Resources

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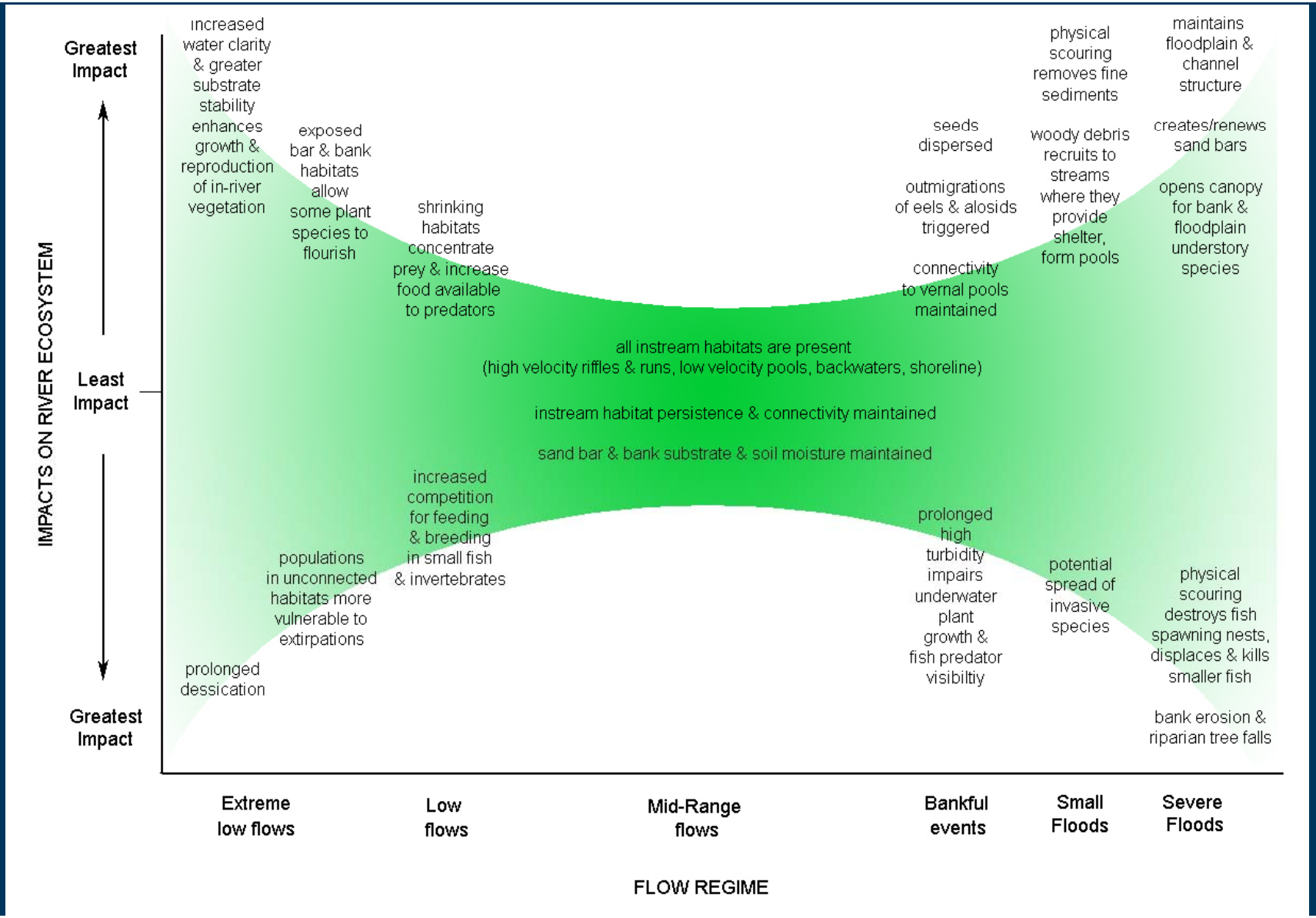
A balance to every flow

Figure 39, page 74.



Flow components leave their mark in the landscape, creating ecological zonations.

Top. Flow component zones can be seen at Mather Gorge, from low to flood flows. The constriction of the river magnifies the vertical height of each zone

Below, tidal zones exhibit similar magnification along the Maine coastline, where tidal amplitude reaches 12 feet.

In-River –
Inundated or Seasonally Exposed.

Submerged:
- Water
- Stargrass

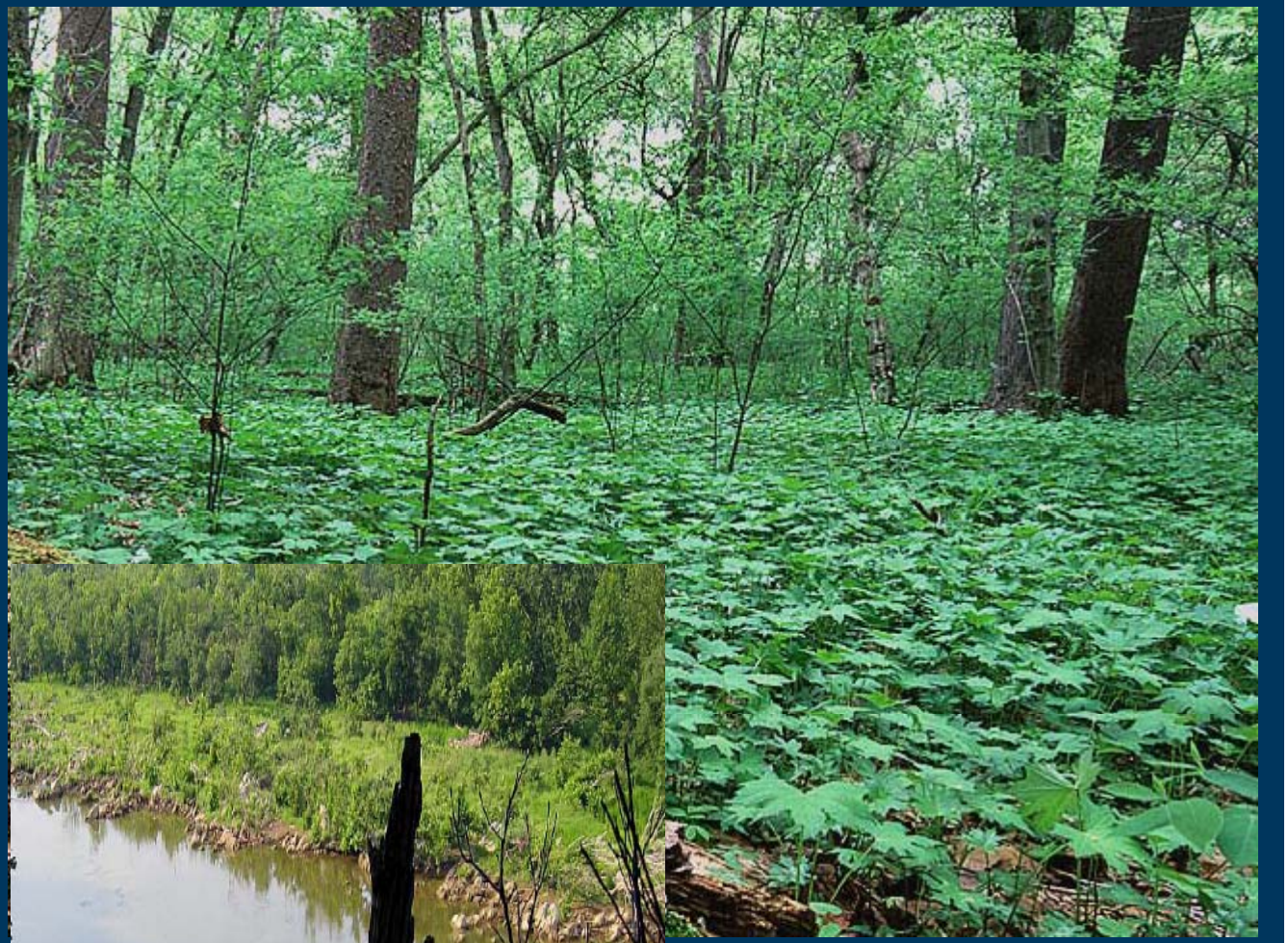
Emergent:
- Water Willow

Bank and Bar-
Water Edge to Bank Full (0.5-2 yr RI)

Flood battered hardwood-shrubwood, , Willow, River Birch, Silver Maple, Sycamore, Switch Grass, Big Bluestem

True Floodplain – Small Floods above bankfull (2-10 yr RI)

- Silver Maple, American Elm, Sycamore, PawPaw, Green Ash, Boxelder
- Less Battered.
- Special Communities:
- Riverside Prairies

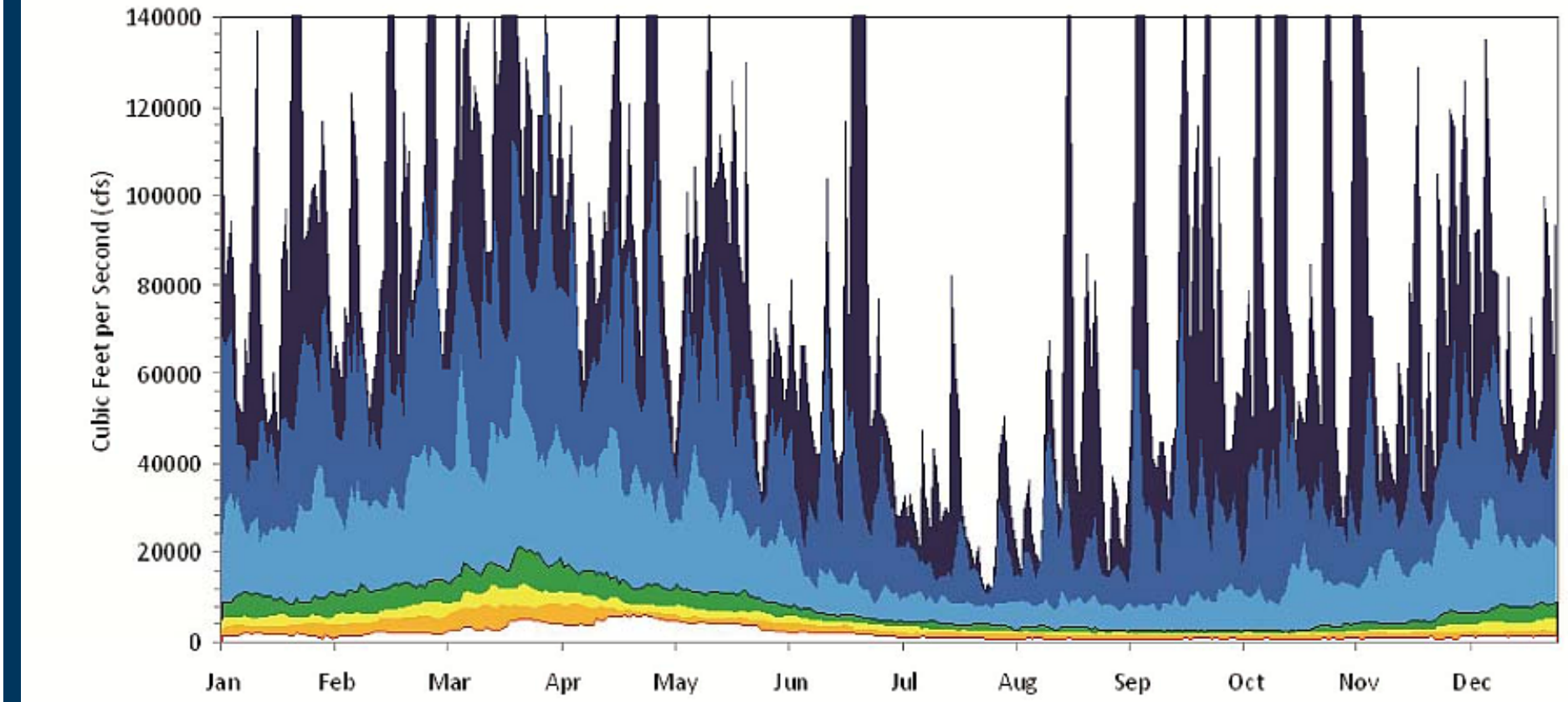


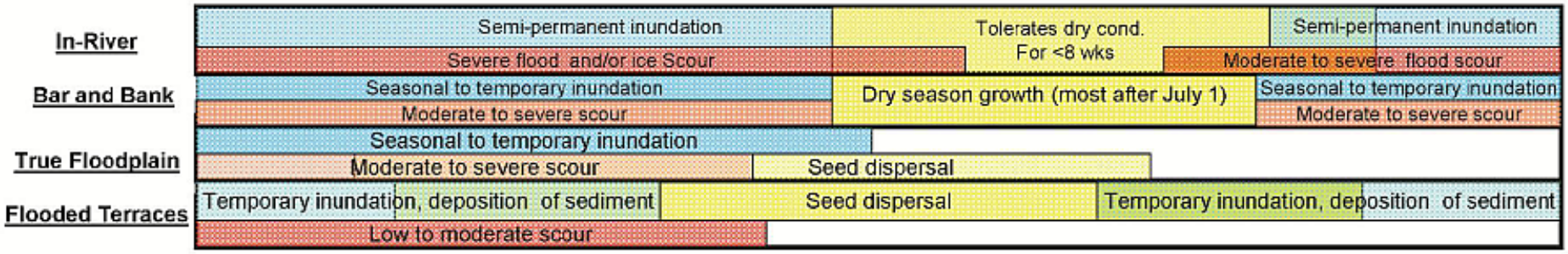
Flood Terrace – Extreme Floods (>10 yr RI)

Rich Forest -Boxelder stands, White Ash, Sugar Maple, some Red Oak, Tulip Poplar.

Special Gorge Communities: Bedrock Terrace Oak-Hickory/Virginia Pine Forest

Plant community needs in relation to flow in the Potomac River.

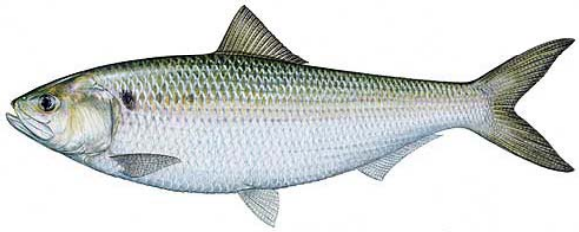


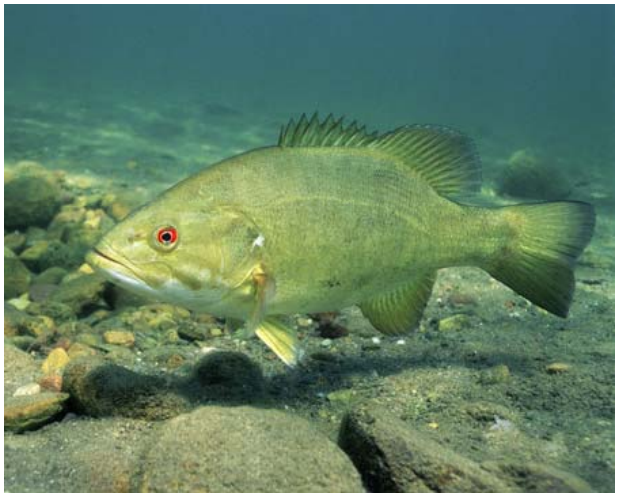


Flow-Ecology Hypotheses for Potomac Nontidal River Plant Communities

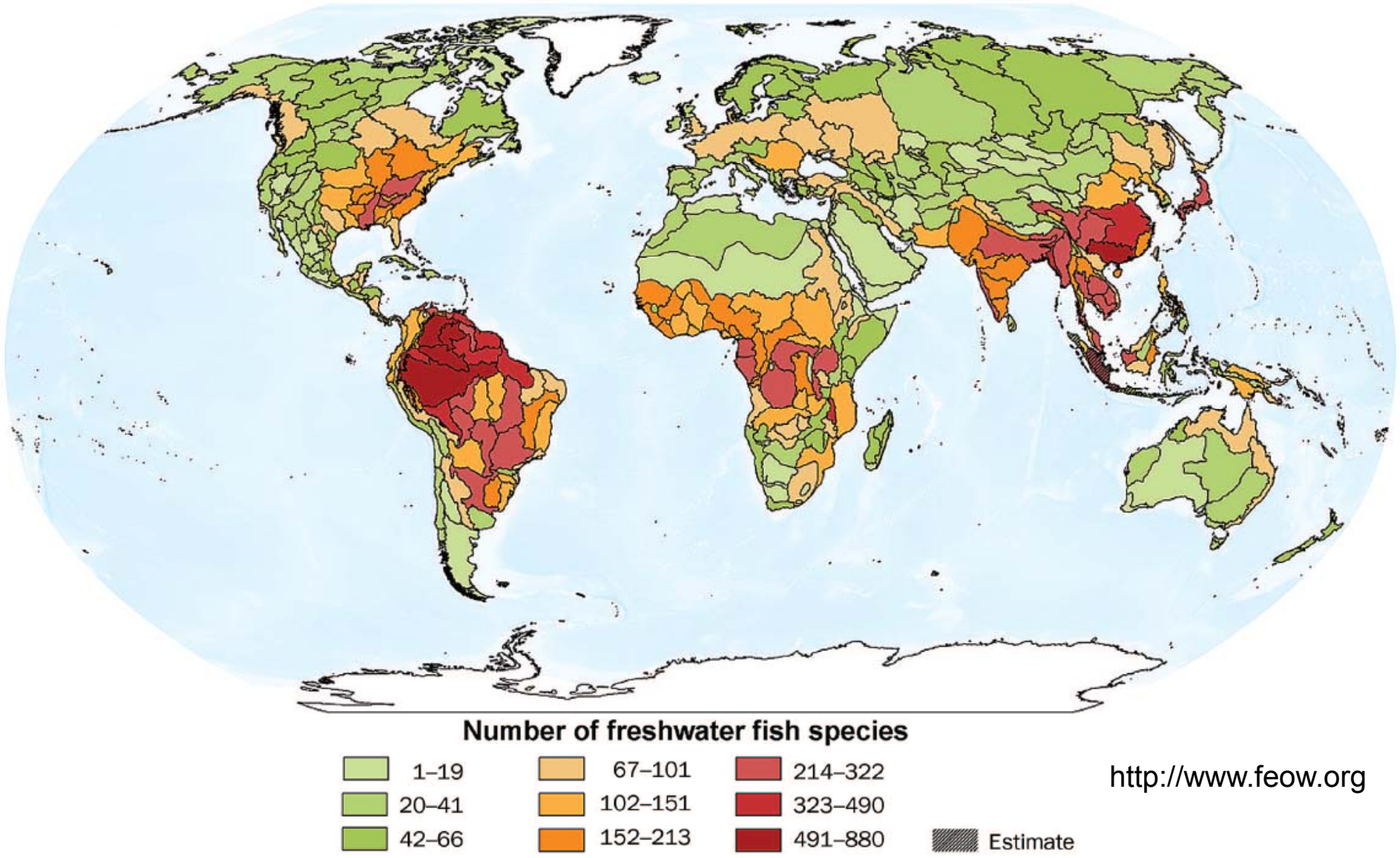
- Submerged aquatic plants experience their greatest growth and reproduction during years with lower flows during the growing season due to increased water clarity and greater substrate stability.
- Floodplain plants depend on floods for seed dispersal, deposition of sediment to maintain floodplain surfaces and enrich soils, removal of debris and potential competitors from germination sites, and to provide adequate moisture conditions for germination and growth.
- Flooding-caused tree falls promote diversity by providing openings in the canopy and opportunities for pioneer and understory species that do not occur during dry years.
- Duration and frequency of floods upon different fluvial landforms is the most important factor determining riparian vegetation communities.
- Species richness of riparian plants increases with topographic complexity of the floodplain.

Fishes of the Potomac River





The Potomac River is part of a global fish biodiversity hotspot.



http://www.feow.org

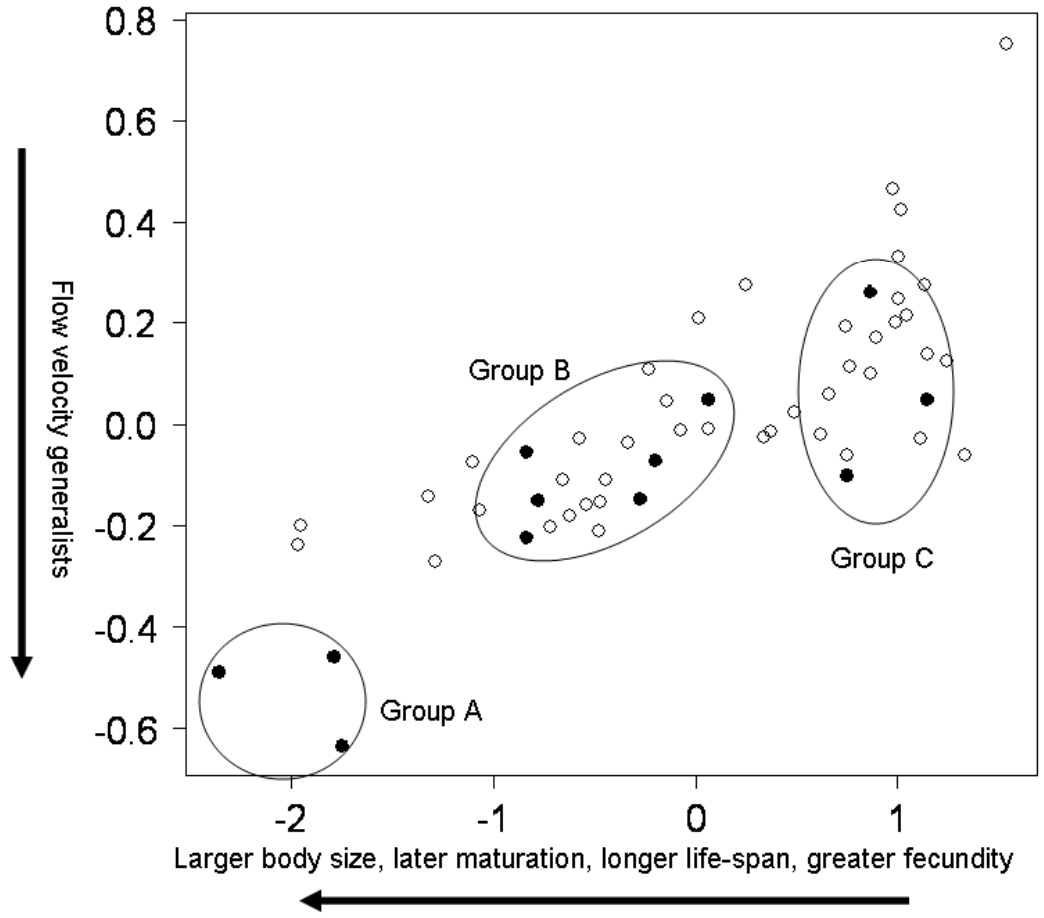
Fishes of the Potomac River

- 102 recognized fish species
- 11 diadromous species
- > 30 introduced species
- 56 are “mainstem fishes”

Fishes of the Potomac River

Species traits analysis

Body size
Age of maturity
Longevity
Fecundity
Spawning season length
Velocity tolerance



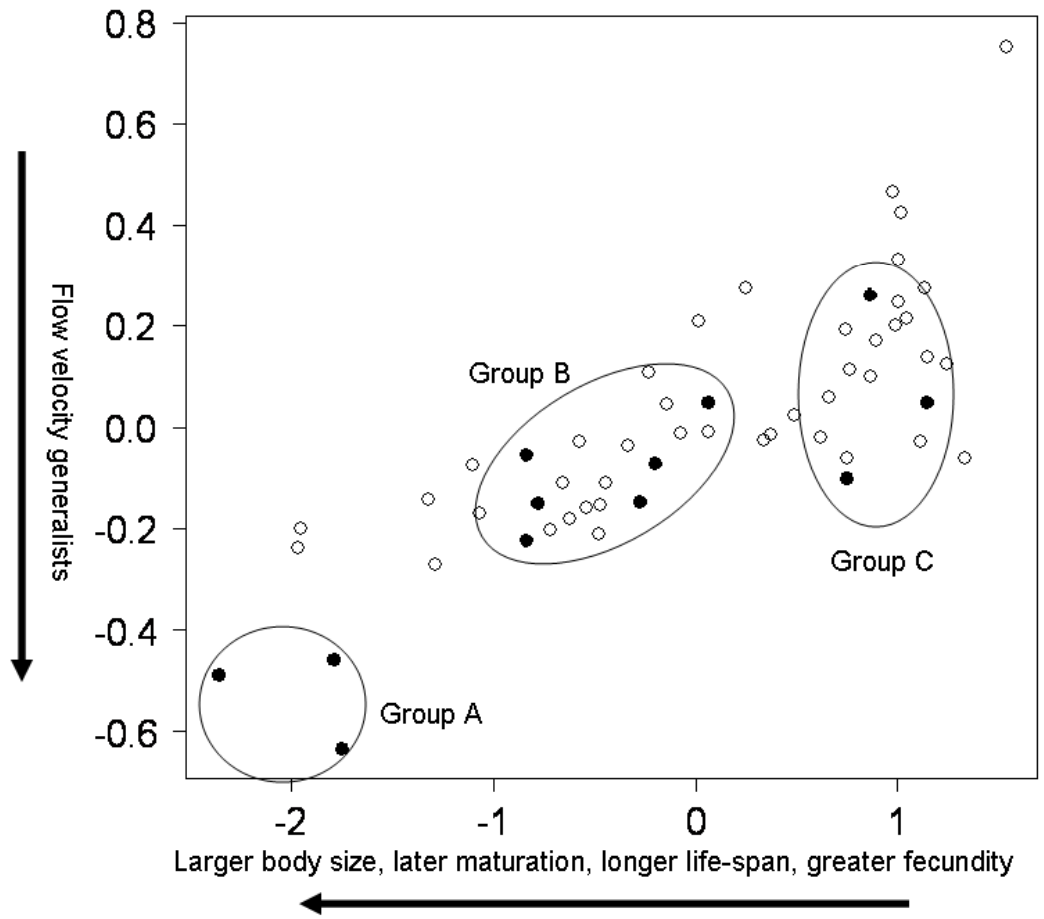
Fishes of the Potomac River

Atlantic sturgeon

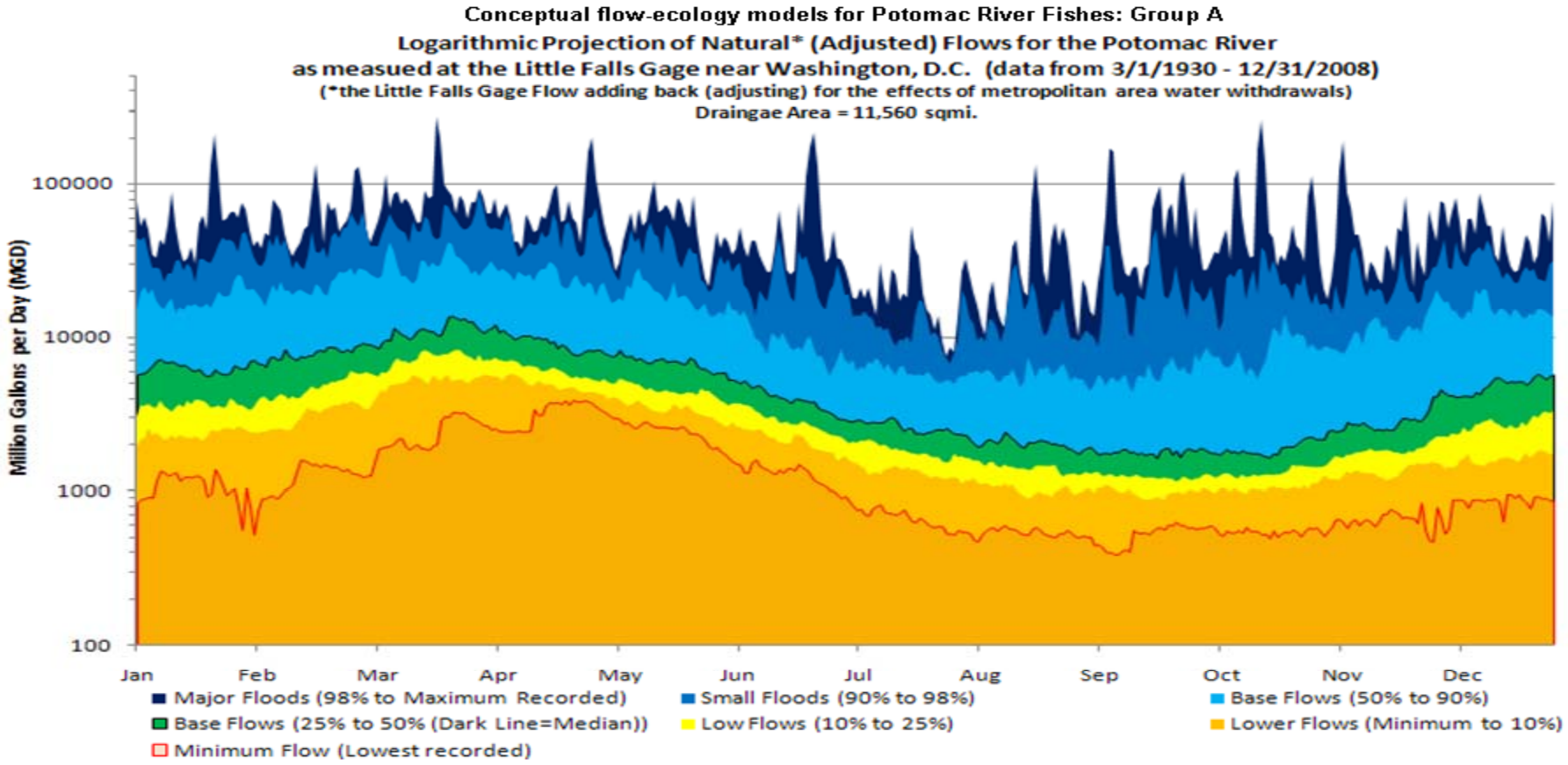
American shad

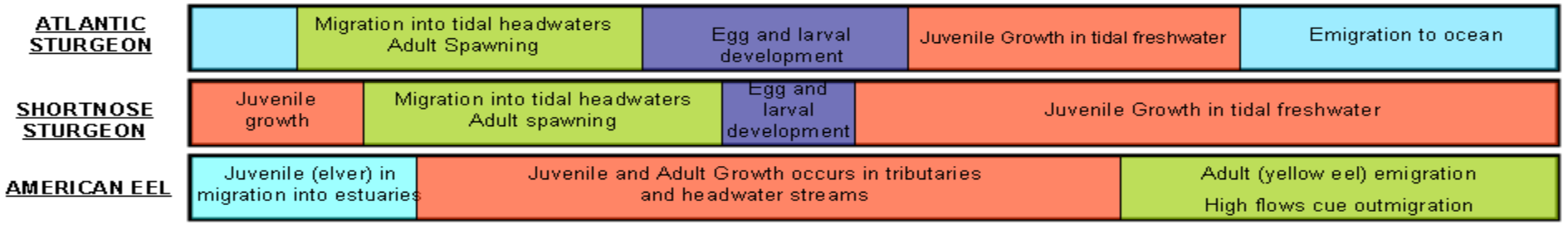
Smallmouth bass

Satinfin shiner



Group A fishes: sturgeon





Flow hypotheses: examples

Out-migrations of American eel (*Anguilla rostrata*) and alosids are triggered by high-flows and associated water quality conditions (i.e., turbidity).

Fishes exhibiting K-selected reproductive strategies will be more vulnerable to stochastic high-flows and floods than r-selected species (e.g., margined madtom, *Noturus insignis* versus white sucker, *Catostomus commersoni*, respectively).

Fishes exhibiting simple lithophilic spawning strategies (i.e., no parental care, gravel-spawning species) will be influenced by stochastic flow variability more than other reproductive strategies.

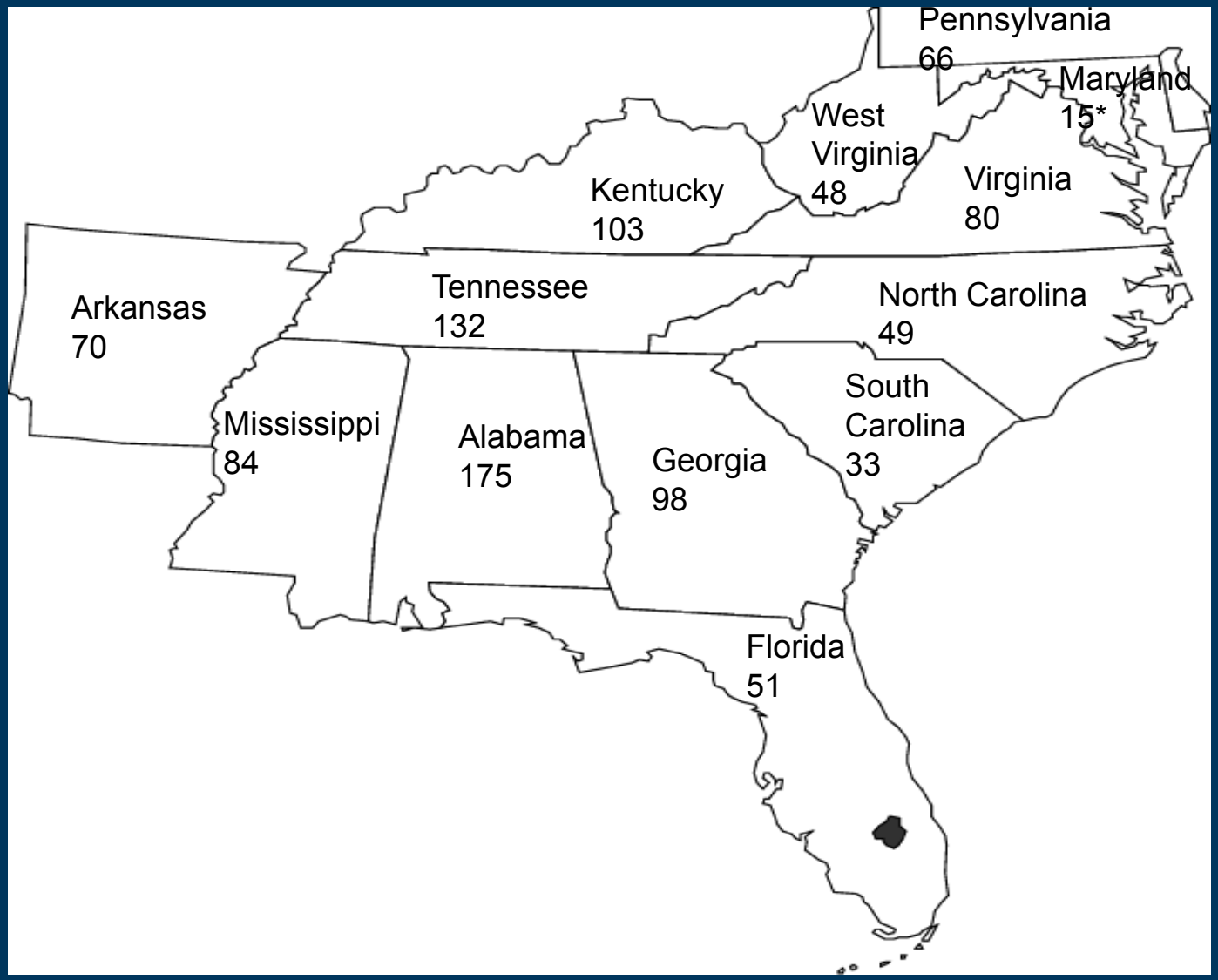
Bedrock-dominated river reaches will be more prone to high-flow extirpations than freestone-dominated river reaches (i.e., microhabitat refugia).

Freshwater Mussels of the Potomac River

Potomac Large River Environmental Flow Needs Expert Workshop

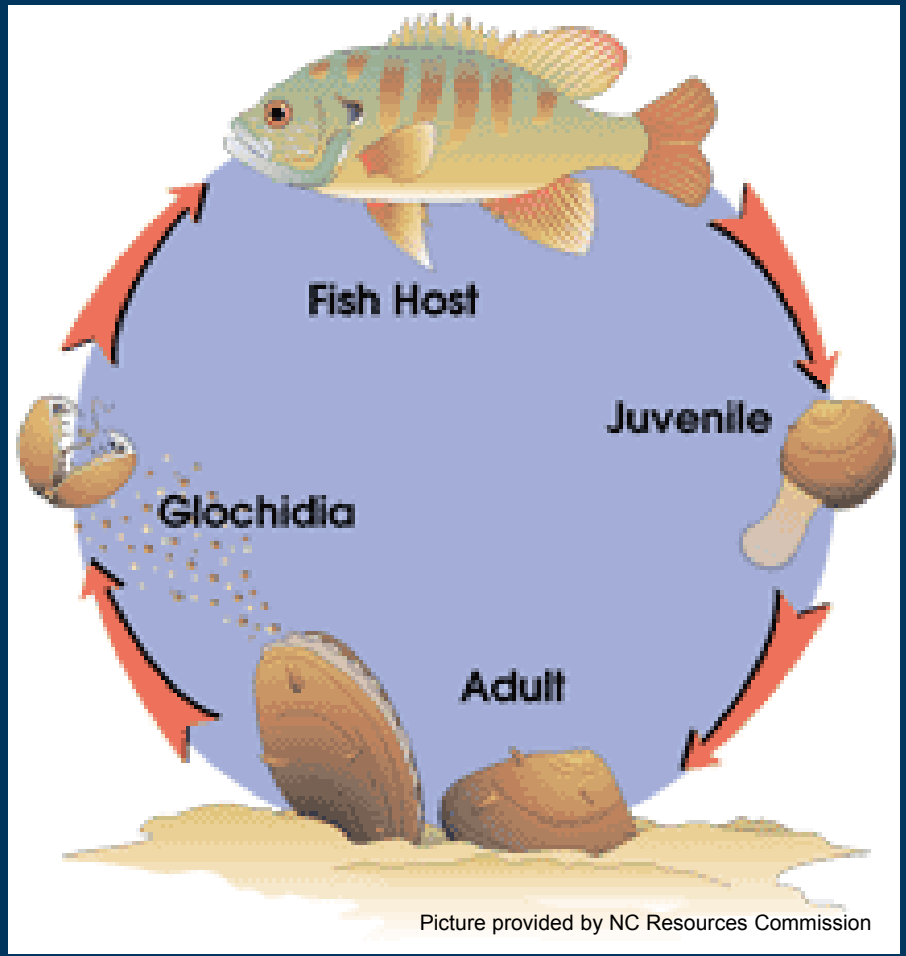
September 22, 2010

Freshwater Mussel Species Richness in the Mid-Atlantic and Southeastern U.S.



Mussel Life History

Life Cycle



Picture provided by NC Resources Commission

Why Do We Care?

Biodiversity

Largest diversity in the world

297 species in North America

72% imperiled
(E, T, SC)

43.2 % T and E

27.7 % Endangered

7.1 % listed & possibly extinct

USGS
science for a changing world

Why Do We Care?

Economic Value

USGS science for a changing world

Why Do We Care?

Ecosystem Function

Shells 'R' Habitat

Riverbed Stability – bind the bottom

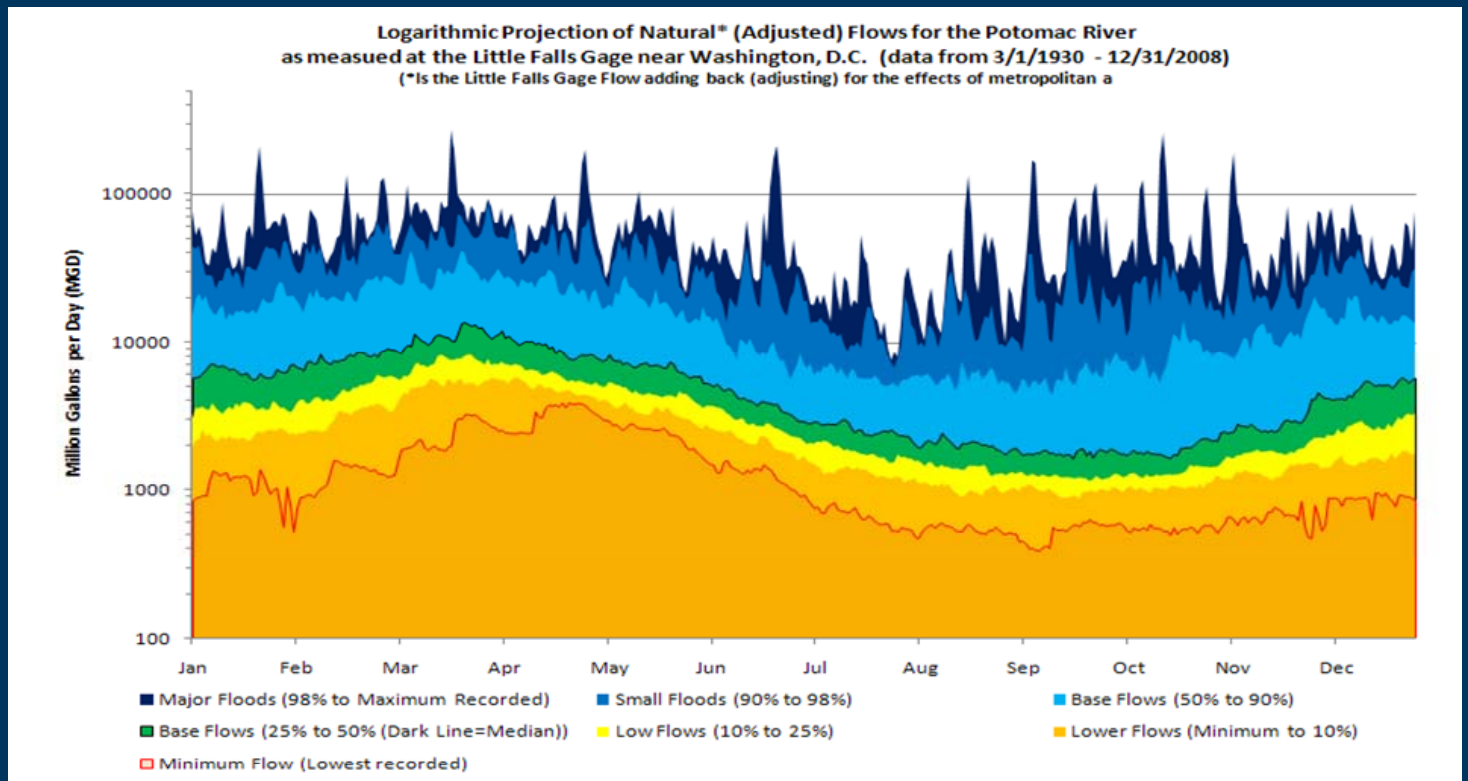
Bioturbation
- O_2 and H_2O content

Material Processing
↑ Light
↓ Particulate Nutrients (N, P)
↓ Suspended Particulates
↑ Sediment Enrichment
↑ Dissolved Nutrients

Examples of low flow and drought effects on freshwater mussels

- Flow velocity <0.01 m/s mortality increased
- Dissolved oxygen < 5 mg/L mortality increased
- *Elliptio complanata* considered tolerant
- Rare and riffle species most sensitive
- Behavior change triggered by low DO and temperature
- Early life stages sensitive to high temperature

Mussel Relations to Potomac River Flow Regime



US Army Corps of Engineers

The Nature Conservancy

USGS science for a changing world

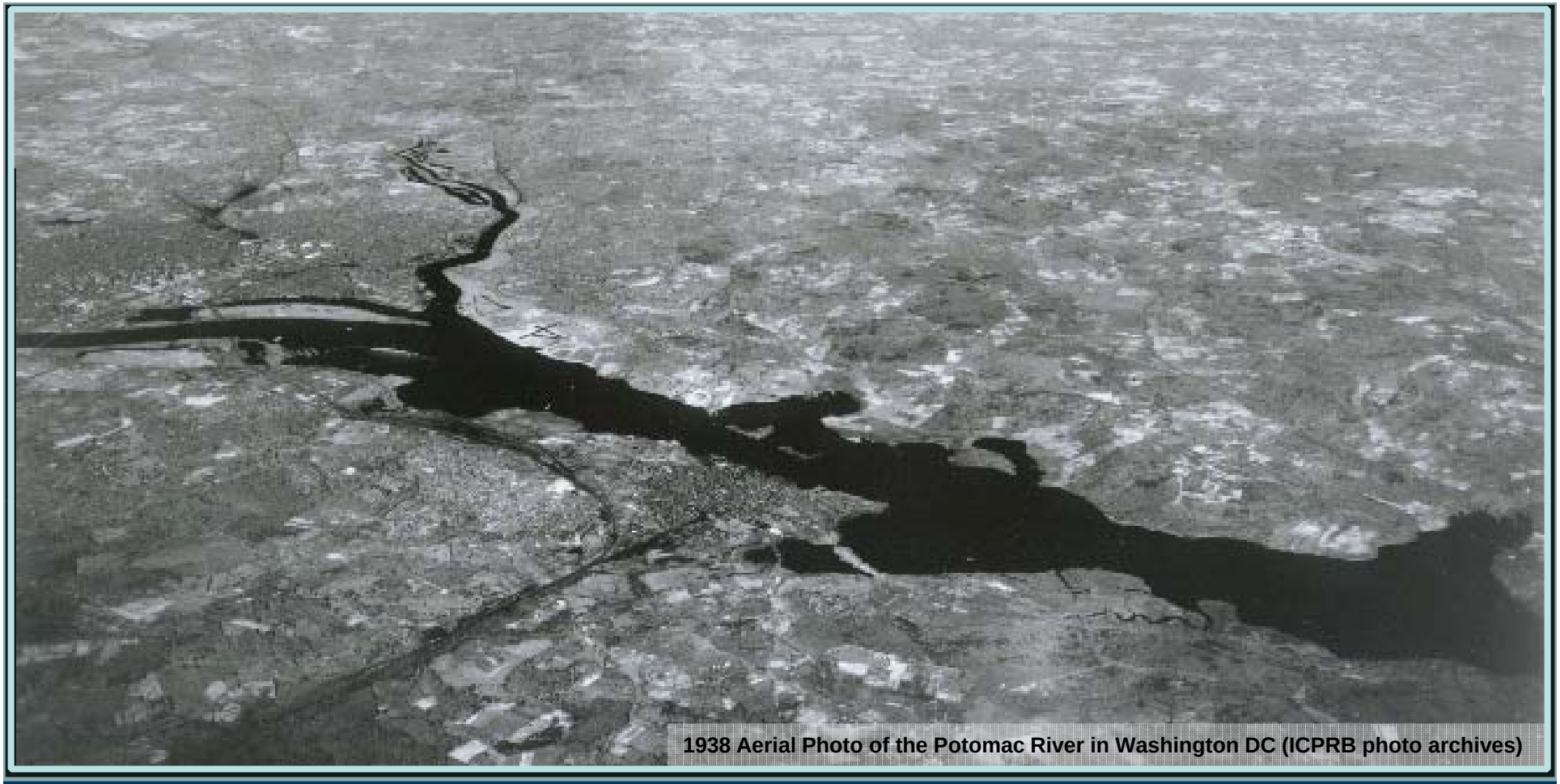
Flow hypotheses: Examples

Winter flow conditions will influence recruitment in long-term brooding species more than in short-term brooding species

Recruitment in short-term brooding species will be influenced by stochastic effects of peak-flows more than long-term brooders

Mussels inhabiting deep water will be less subject to drought than shallow water species

Mussel fish host generalists are less subject to flow-induced extirpation than fish host specialists



1938 Aerial Photo of the Potomac River in Washington DC (ICPRB photo archives)

Tidal Fresh Segment of the Potomac River Estuary

Claire Buchanan (ICPRB)
R. Christian Jones (GMU)
Richard Kraus (GMU)

The Potomac Tidal Fresh Segment

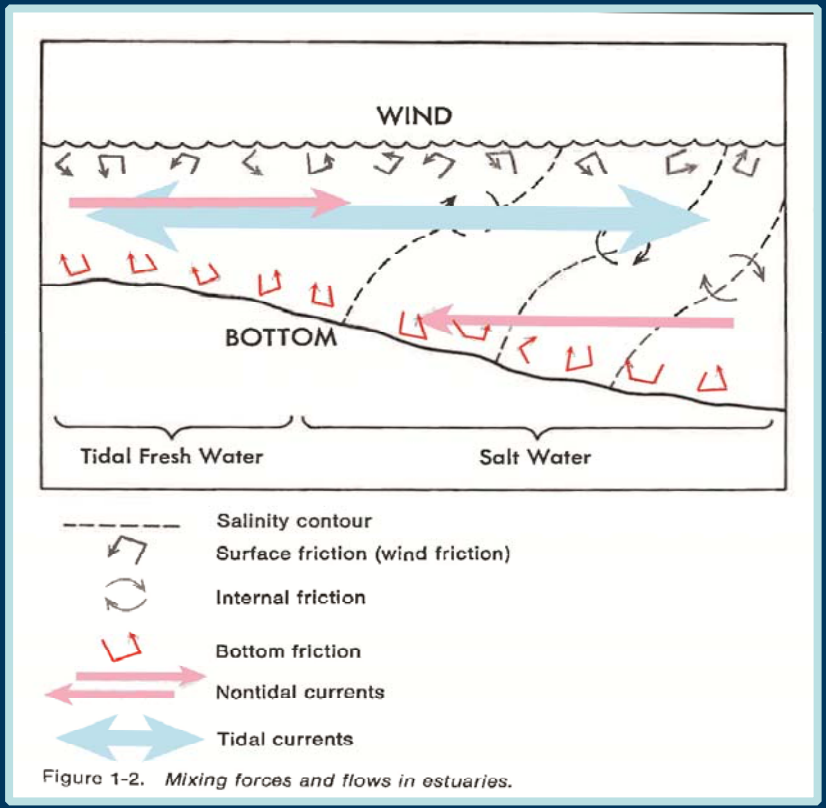
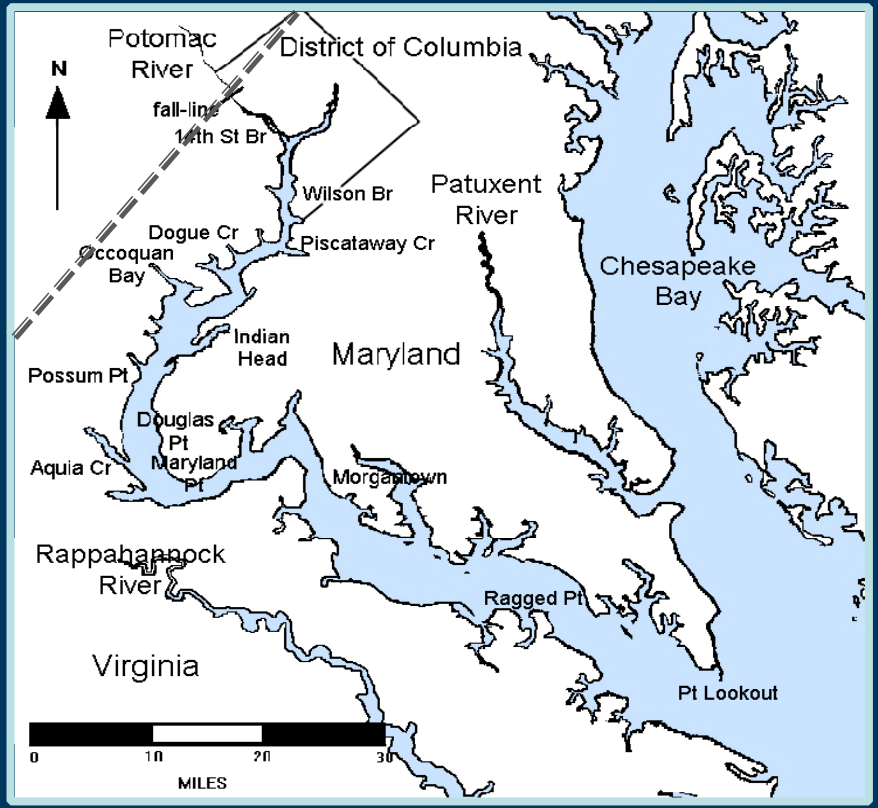


Figure 1-2. *Mixing forces and flows in estuaries.*

From Lippson et al. 1979



ICPRB

The Potomac is a “partially mixed” estuary with mean tidal currents up to 80 cm/sec.

Approximately 78% of freshwater comes from the Potomac River at the fall-line and 22% comes from tributaries in the Coastal Plain.

The Potomac Tidal Fresh Habitat

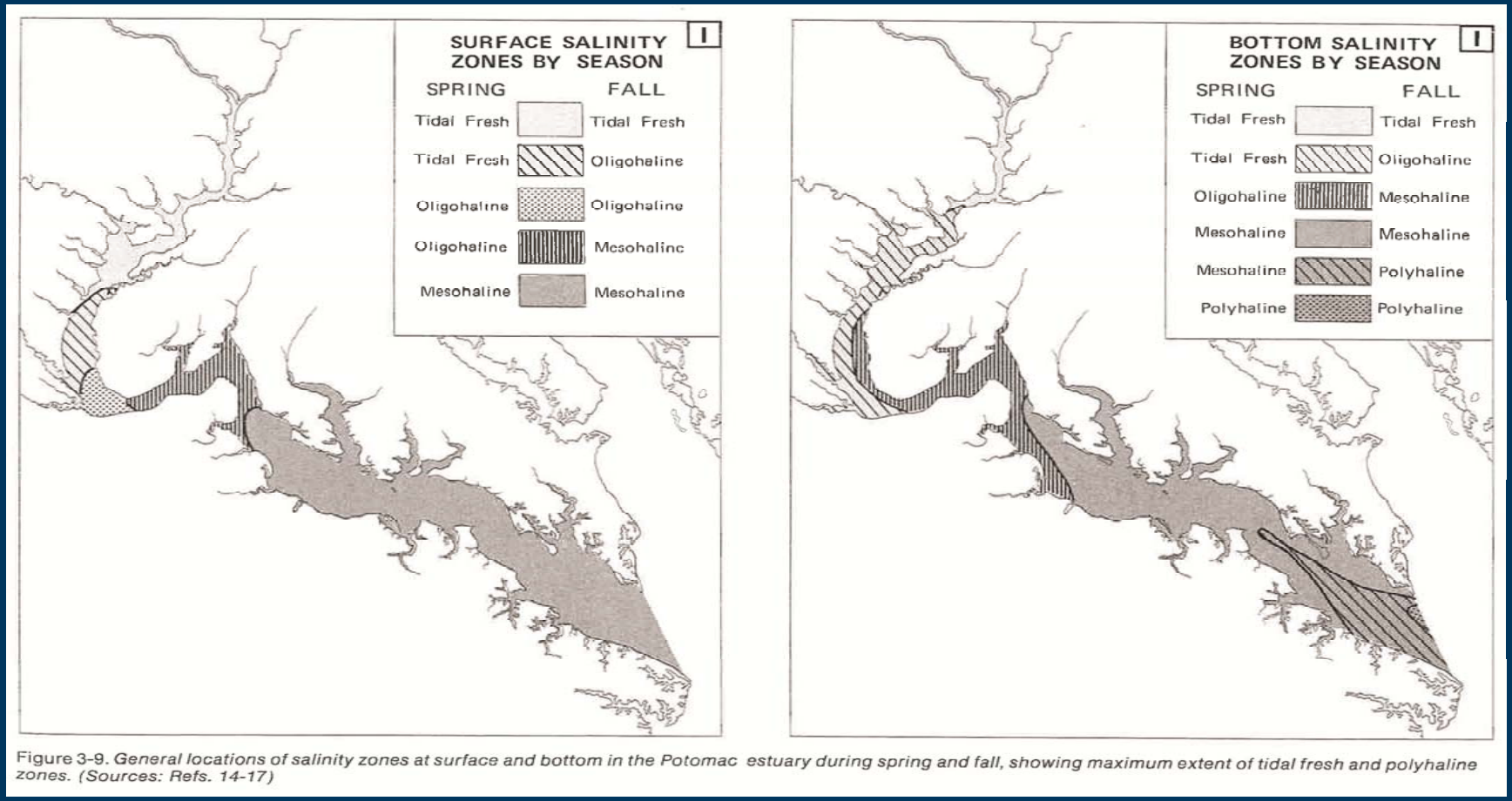


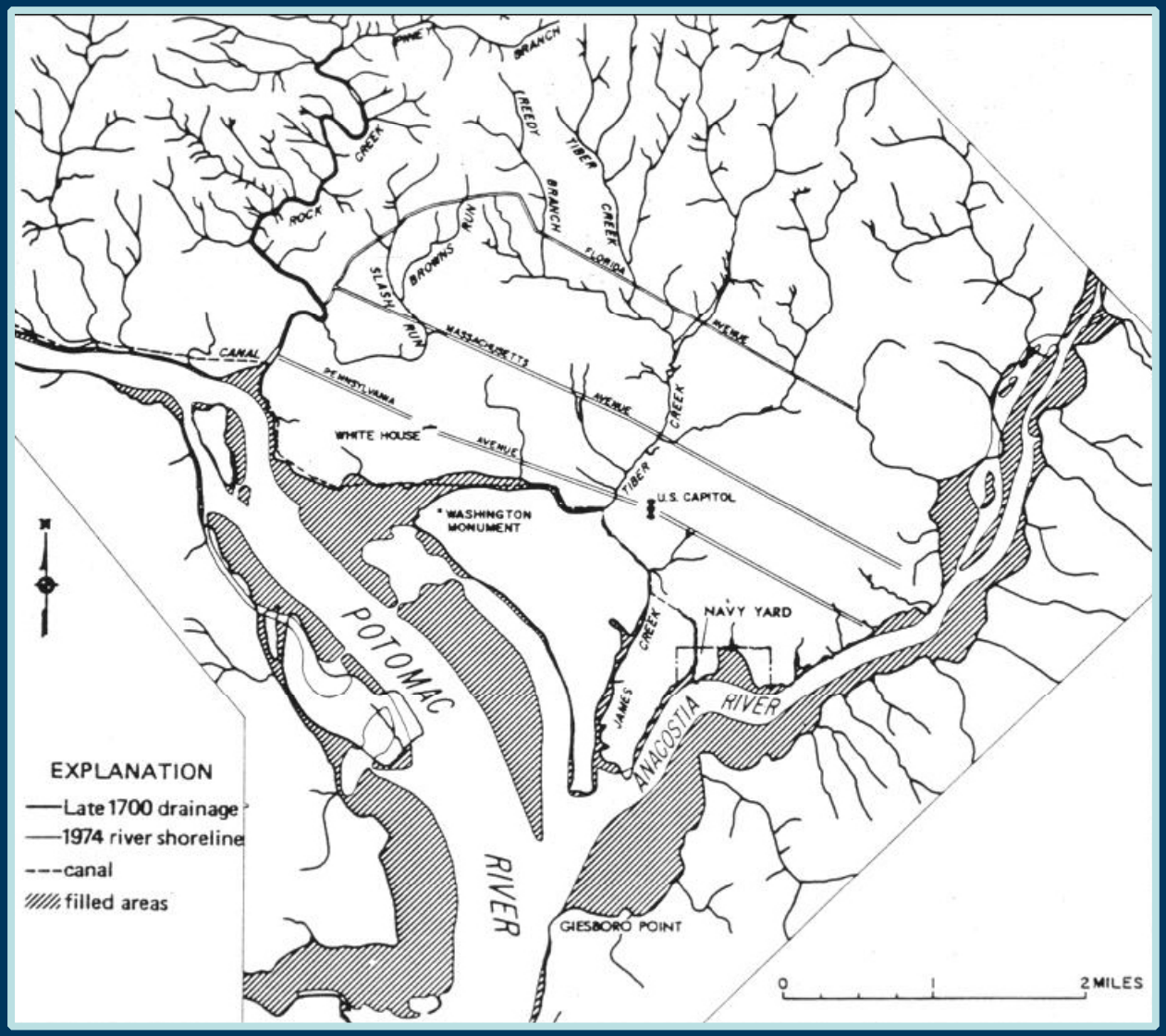
Figure 3-9. *General locations of salinity zones at surface and bottom in the Potomac estuary during spring and fall, showing maximum extent of tidal fresh and polyhaline zones. (Sources: Refs. 14-17)*

From Lippson et al. 1979

Salinity is a surrogate measure of freshwater flow. Tidal fresh is ~ 19 - 40 miles long.

High flows = greater freshwater volume; low flows = greater brackish water volume.

The Potomac Tidal Fresh Habitat



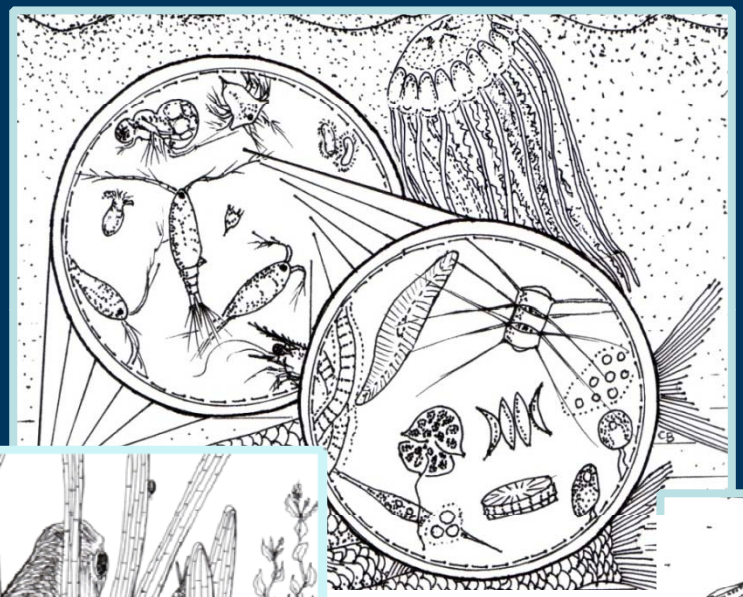
The tidal fresh segment is irreversibly longer and shallower than it was three centuries ago.

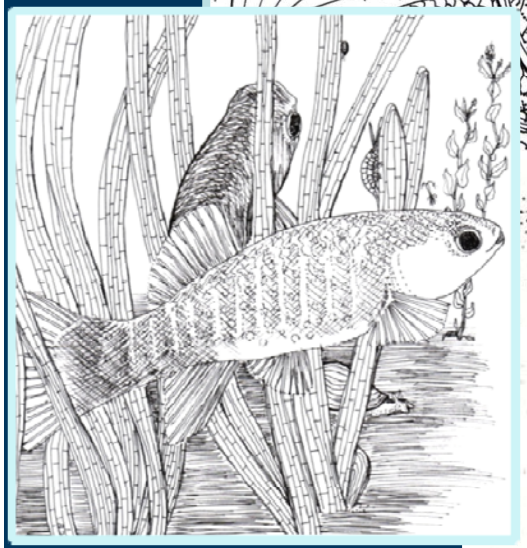
Freshwater now travels through a 1 mile river segment in about ¼ the time it once took.

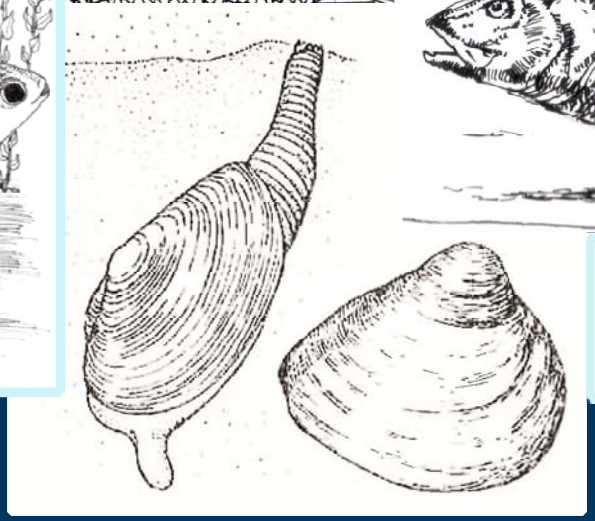
Is the *volume* of freshwater habitat the same? Might be greater now (deforestation → higher mean flows).

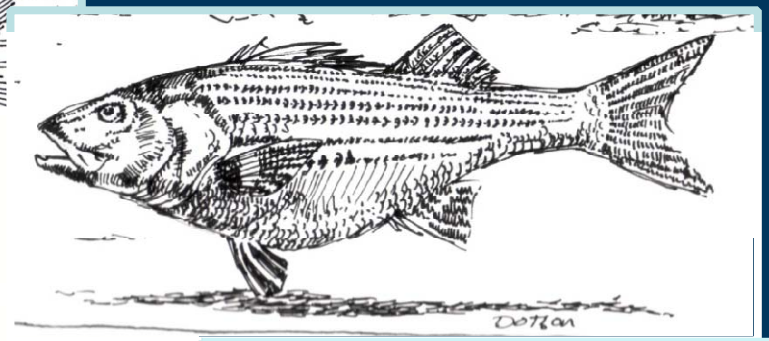
Map from ICPRB archives

Estuarine Indicators









Communities	Phytoplankton Aquatic grasses (SAV) Zooplankton Benthic “infauna”
Species	Shortnose sturgeon Atlantic sturgeon Striped bass White perch

Tidal Fresh Flow-Ecology Hypotheses

Salinity, and specifically the location of the "salt wedge," **is a surrogate measure of freshwater flow** in the upper, tidal fresh estuary

A range of freshwater flows gives **intermittent opportunity** to both freshwater and brackish water species and produces a biologically diverse estuarine ecosystem.

The flow "needs" of most freshwater species in the tidal fresh segment are typically a reflection of their **salinity preferences and tolerances**

High flows, in conjunction with the daily light cycle, temperature and/or turbidity, **cue diadromous fish migrations** into estuaries and rivers in spring and out-migrations in autumn

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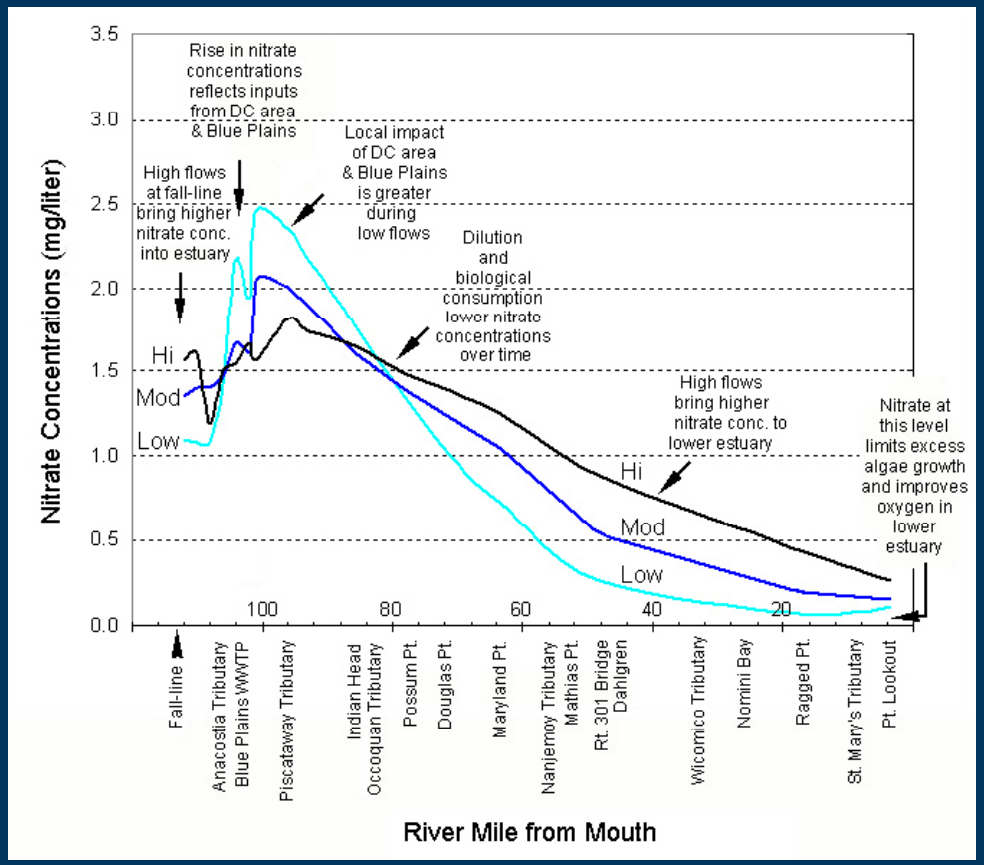
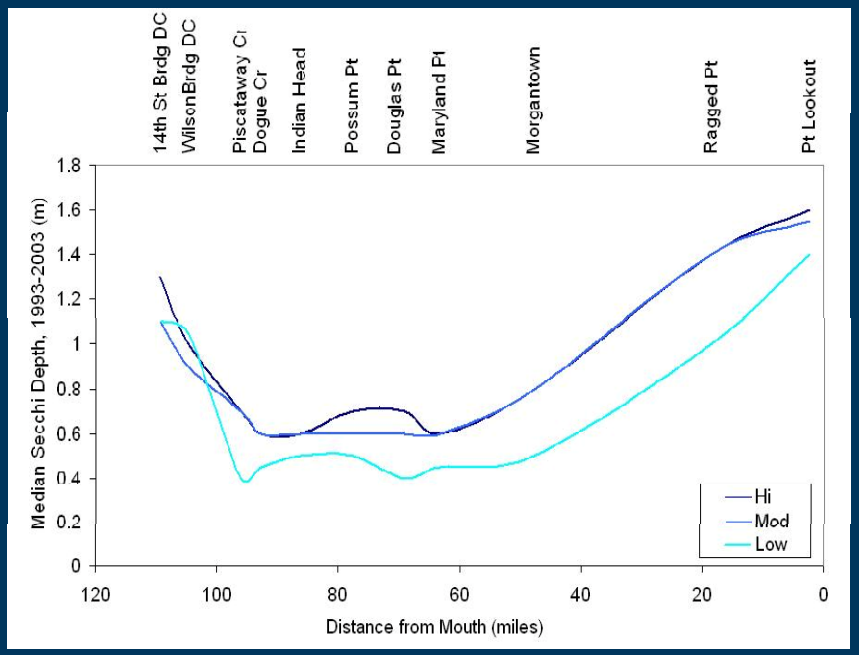
Poor Water Quality Confounds Potomac Flow–Ecology Relationships

Wastewater returns and runoff to the estuary in and around Washington DC confound the expected tidal fresh flow-ecology relationships.



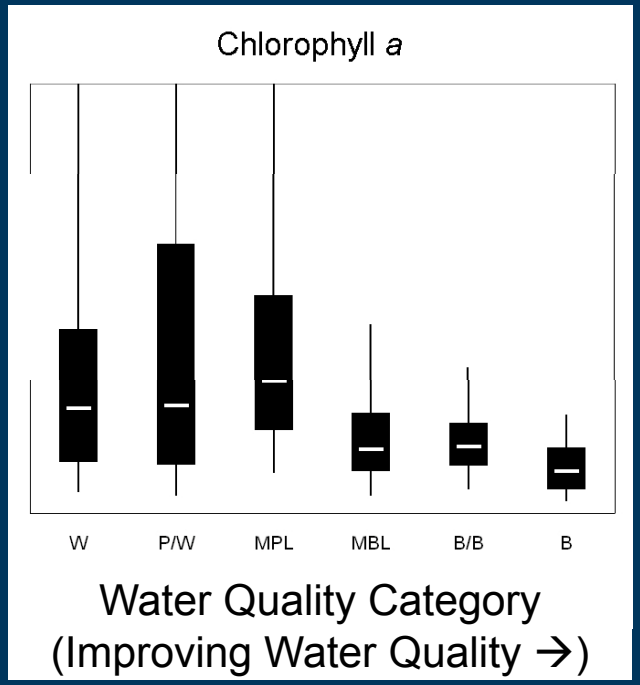


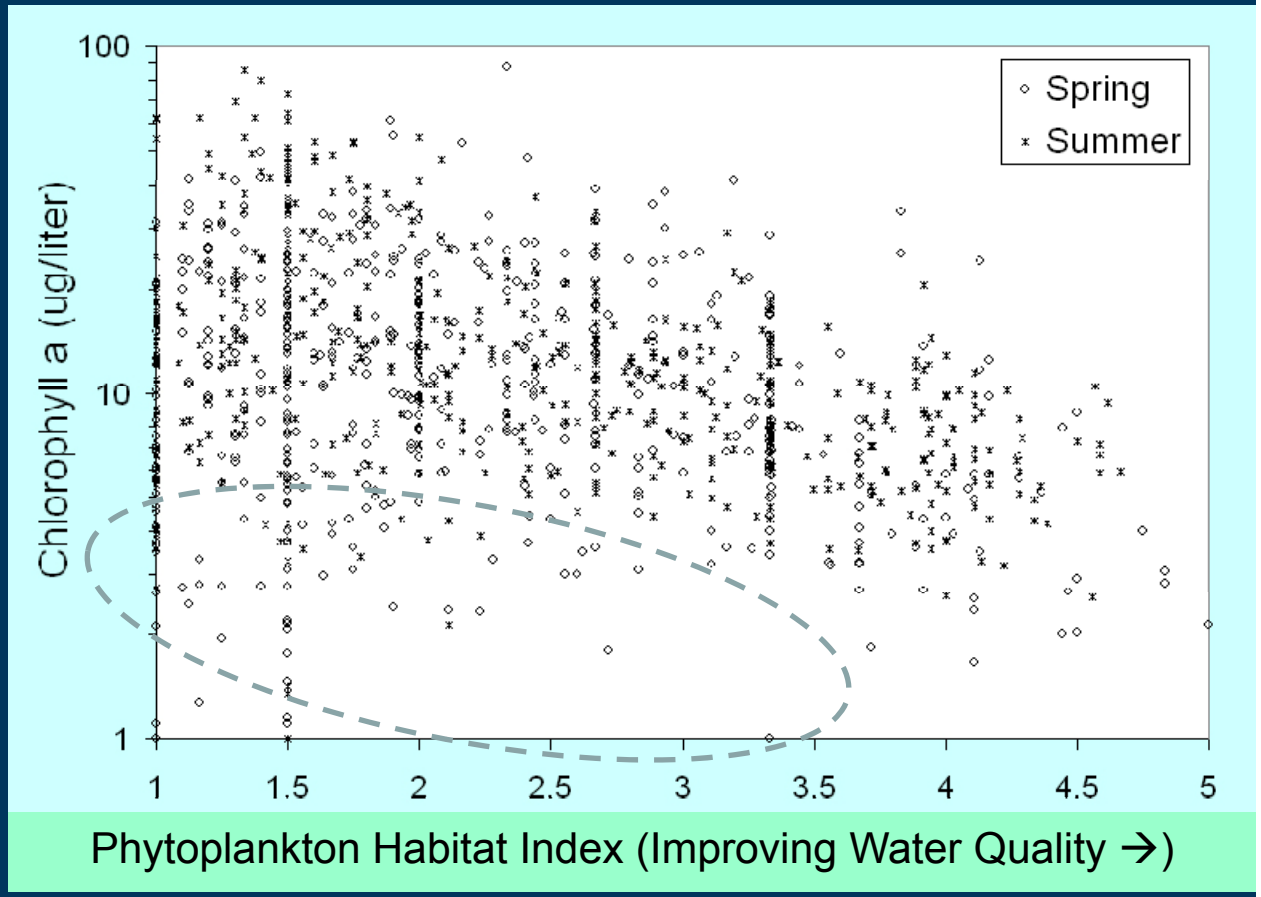
Nitrogen concentrations are *higher* and water clarity is *poorer* during prolonged low flow periods

Does Flow Trump Water Quality?

Flow does not change Chesapeake Bay phytoplankton responses to water quality (N, P, clarity) *except* when cells are washed out of tidal fresh by very high flows.

Median typically varies only +/- 2 ug/liter between 5 flow categories





Data are from Chesapeake Bay, all salinities, spring & summer "growing" seasons, 1984 - 2005

Tidal Fresh Flow-Ecology Hypotheses

Eutrophication and sedimentation of the Potomac River have changed (confounded) many estuarine flow-ecology relationships:

- The tidal fresh reach of the estuary is **irreversibly longer and shallower**
- **Wastewater returns to the tidal fresh estuary** increase rather than decrease nutrient concentrations during low flow; high flows dilute tidal fresh nutrient concentrations
- **Water clarity is poorer during low flow** periods rather than high flow periods
- **Plankton blooms now occur predominantly in summer** rather than spring and are not as closely linked to high flows in spring as they once were
- **Uneaten phytoplankton sink,** cause bottom layer hypoxia and anoxia that stress and block migratory fish and benthic life stages

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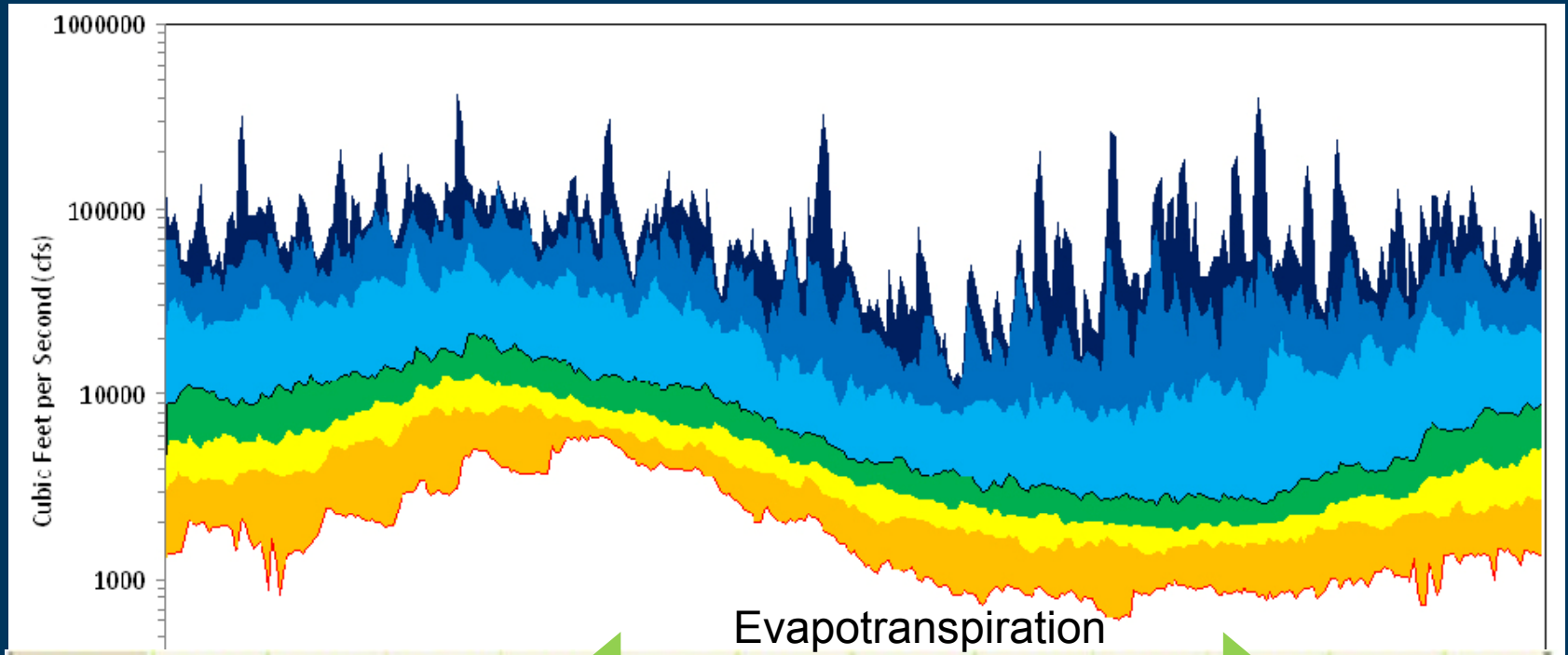
More Trees = More Evapotranspiration
More People = More Consumptive Loss

Little Falls Unadjusted Flow (cfs)



Mean Rain fall (inches)

Tidal Fresh Flow-Ecology Hypotheses

Depending on water quality conditions, a **persistent loss** of freshwater flow could reduce tidal fresh communities & enhance brackish water communities

(e.g., increased consumptive losses, increased forest evapotranspiration)

Depending on water quality conditions, a **persistent increase** of freshwater flow could enhance tidal fresh communities & reduce brackish water communities

(e.g., predicted climate change)

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TIME FOR LUNCH!